DIY Citizen Science: Participatory Linguistics Outreach for Improving Science Trust

Research Thesis

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by

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Abstract

A troubling gap of trust exists between the general public and professional scientists across disciplines and settings; this gap only continues to widen as the politicization of scientific issues continues to dissolve existing trust in science (Fiske & Dupree, 2014). Citizen science programs have historically sought to improve this disconnect by involving everyday people in the gathering and processing of data for standing research projects (Bonney et al., 2009). However, these programs are not created with the goal of improving science attitudes as their primary focus, and their content is often limited to the physical sciences. Instead, language science is a model field for such a program with goals related to science trust, covering topics and ideas that have low barriers to entry for basic understanding, as well as maintaining a solid connection to the humanities and public interest (Honda, 1994).

This project describes a novel approach to citizen science methodologies. Rather than including participants in the collection and analysis of data from existing projects, language science studies can instead be designed alongside the public from start to finish as an educational tool providing insight to each step of the scientific process, answering a question they suggest with methods and analyses they help design. A preliminary run of such an outreach program was conducted over a ten-week period in the summer of 2020. Digital materials were designed for continued interaction over this span of time on an interactive website, and participants created and directed a language science experiment of their choosing. Outcomes from this trial include tracking results from website interactions and participant demographics. Shortcomings and suggestions for improving this method are discussed, and future steps for continued programs are detailed.

Introduction

The Public Perception of Science

Trust in science and scientists is falling. Though scientists are generally afforded respect in the United States, there is a persistent lack of scientist trust that continues to permeate personal beliefs and actions (Fiske & Dupree, 2014). Many people simply do not fully understand or trust scientists or the work that scientists do. In response to this issue, STEM outreach continues to see a surge in engagement and interest in educational areas, but not always through explicit connection to the process of scientific research itself and these issues of public attitudes. Addressing these concerns is a responsibility of not just educators but also professional researchers; communication with the public is an under-trained yet important part of the scientific process itself, and focusing on this outreach can both improve public understanding of science as well as a professional's methodology and capacity for scientific work (Wu, 2017).

Public trust in science and scientists is important for public health and issues related to science literacy. The COVID-19 pandemic has highlighted the pressing need for improving the public's general science literacy and trust of science and scientists. As increasing numbers of people choose the internet and specifically social media for their news, a different kind of media understanding is needed for accurate knowledge dissemination and selection (Chesser et al., 2020). Inconsistent and dangerous leadership (Hatcher, 2020) along with perceived gaps in professional advice and qualification have continued to erode public trust in science and scientists (Rajkhowa, 2020). It is imperative that these gaps and beliefs be adjusted for other issues that should concern the general population, including not only the possibility of other infectious diseases in the future but also for other interfaces of research and the public such as

the pursuit of renewable energy in the face of climate change or the growing need for and confusion around the inclusion of bilingualism in the classroom.

However, this level of trust is highly correlated with an individual's set of experiences with science in the past (Funk et al., 2019). Doing science, not just learning about it, is a powerful way of changing minds. Finding new and creative ways to involve people in science and the production of science, not just in educational programs related to the topic, will ultimately be an important key to improving these attitudes. Yet without the framework of formal educational settings, it can be a considerable hurdle to simply reach the public that ought to experience these programs.

Informal Education

Informal science is a critical opportunity for this type of education as formal education is a limited resource with limited reach and duration in the lifespan; Americans spend not even five percent of their lives in the classroom, meaning that much of their lifelong learning needs to happen through informal channels (Falk & Dierking, 2010). Informal environments can include places explicitly created for learning, like science museums and libraries, as well as other more open forums, like online spaces and community centers. Within science classrooms, hands-on activities are found to improve science understanding (Zhan, 2014), and extending these activities to informal environments allows increased opportunities for audience engagement. When legitimized science can be found and engaged with in unexpected places and ways, the informal setting allows openness to experience and for attitudes to change (Bultitude & Sardo, 2012).

Settings like museums that traditionally conduct informal science education often have some limitations, however. Such institutions are limited in reach, often inaccessible to people with lower incomes, and positioned in a way that can exclude people of color in their operations and activities (Dawson, 2014). Another shortcoming of structured visits to informal science institutions is that those who consider themselves to be non-science people continue to maintain that self-image; breaking down these fixed identities through engagement with the process of doing science may adjust for this issue (Shaby & Vedder-Weiss, 2020). Thus, finding alternative methods of engagement that can circumvent these problems, particularly in the ever-growing space of the internet, is a worthwhile pursuit.

Formal education is not isolated from informal education, though. Finding ways to incorporate classroom education within the efforts of museums or universities can allow for exciting opportunities as well. Starting with an isolated context like a website and transitioning to building materials for more formal contexts like classrooms would allow teachers to approach instruction with a different strategy that ties informal outreach to new contexts (Hofstein & Rosenfeld, 1996). Changing science attitudes should be pursued at all levels, and more effort should be put toward finding unique bridges between the classroom, the informal setting, and scientists with new materials and approaches.

The Role of Language Science

Though there are ongoing efforts to promote STEM interest and science understanding within the public, there still exists a persistent and troubling gap in public engagement with the topic (Stilgoe et al., 2014). A common belief in the public eye is that there are ‘science people’ and ‘non-science / creative people’. Despite that persistent myth, not everyone has to be a scientist and pursue such a career or purpose, yet everyone has the power to understand science

and how it works. It is a skill to be honed, and improving this perception of science and what it entails may change the attitudes of the public. Science is not an identity or personality trait, and we should be building an engaged population of everyday scientists.

Language science and linguistics can serve as a bridge or gateway between non-science identity and science understanding and appreciation (Baker, 2020). Examining our own language is accessible to most people. We live our lives almost constantly surrounded by language, perhaps even more so in an evolving world centered on technology and digital communication. It is difficult not to notice differences in the ways people speak or sign or type languages, or quirks we can feel in our minds as we process a sentence. Investigating how these things work and why they work this way is exciting to students and an underutilized introduction to scientific inquiry, promoting that science is not merely a subject but also a method of considering the world around us (Honda, 1994). Language is a powerful connection between science and personal experience, giving it strong potential as the field of choice for changing science attitudes.

In fact, science content that uses language as its medium has been shown to be successful for educational experiences outside of the classroom. Science museum visitor engagement in language science experiments and outreach demonstrations are promising additions to informal science experiences (Wagner et al., 2015). This includes not only outreach for the sake of education, but also through incorporating the public in the process of research as it interests them personally. By allowing people to explore topics and problems they care about in their own research, science and health literacy can be promoted and improved (Ozer, 2017). In this way, language can be used as a gateway science to connect participants with the scientific process and improve science trust through a subject that has less scientific baggage assigned to it already.

Citizen Science Approaches

If doing real science and connecting to topics that people care about are important for educational outreach, improving the public perception of science and scientists ought to involve education through actual experience with the scientific process. "Citizen science" is an exciting way of involving everyday people in real world research through informal, often digital, educational environments (Bonney et al., 2009). This approach involves engaging the public as if they were scientists themselves and allowing them to participate in real-world research to better understand what science is and how it works. This moves beyond simply involving people as research participants and instead casts them in the role of the researcher in some limited capacity. Representative tasks in citizen science programs include collecting data on butterflies and moths across North America by getting out into the field and taking photographs (https://www.butterfliesandmoths.org/), or processing images of plant fossils to better understand how the atmosphere has changed over time (https://www.si.edu/fossil-atmospheres). However, this is most often applied to the physical sciences, leaving social and behavioral science behind and furthering the misunderstanding of what can or cannot be studied scientifically.

Other citizen science programs have found good success in their settings and fields. The most popular examples, such as the brain-mapping game EyeWire or the protein unravelling of Foldit, have reported hundreds of thousands of volunteers (Waldispühl et al., 2020). That benefits the professionals who created these projects, but involving the public in the scientific process also does improve their appreciation and understanding of science and how it works (Bonney et al., 2016). Becoming the scientist themselves allows participants to better understand the roles, responsibilities, and considerations that professional scientists face. Simply being around science and engaging with the process of recording butterflies or analyzing fossils

increases students' perception of their own scientific abilities, and thus their identity as someone who can do science (Hernandez-Matias et al., 2019). Doing science through the performance of science roles improves science identity and an individual's motivations and aspirations for science in the future (Starr et al., 2020). In this way, citizen science can improve multiple facets of an individual's relationship with science and the scientific process.

This development of a science identity can also contribute to a student's potential to enroll in scientific higher educational institutions, particularly among low-income and underrepresented populations (Piatt et al., 2019). This science identity is crucial to an individual's willingness to engage with difficult topics using virtuous discussion and accurate evaluation of information, particularly in a post-trust and politicized society (Lapsley & Chaloner, 2020). Doing science itself through citizen science projects means aiding in the construction of this science identity, improving personal outcomes, and promoting a perspective change at the societal level as well.

The topic area of linguistics, the practice of citizen science, and the goal of improving science trust can all be combined for a singular program. Following the baseline principles of informal learning, effective methodologies of changing science attitudes, the value of language science as a conceptual bridge, and the participative advantages of citizen science initiatives, this paper proposes a novel methodology of online science outreach. Rather than focusing on public engagement through outsourcing existing project work to everyday people, this paper's citizen science project encouraged participants to collectively create their own science experiment through asynchronous, guided weekly activities. Such a concept combines the approachability and wide interest found within language, the accessibility and reach of online informal

educational spaces, and the practical experience of citizen science with direct engagement and input from participants for the project's entire duration.

Concept

Overview

The BLNDIY (Buckeye Language Network Do-It-Yourself) Citizen Science project was launched as a structured program to engage the public in a fully digital implementation of language science outreach aimed at involving participants in the full process of real research activities. Rather than engaging with an existing academic study as participants or as data processors, the public instead was given significant agency to develop their own experiment in tandem with professional language scientists. This design allows for the benefits of engaging in real science work to better understand science, but in a field less typically seen in outreach activities. All this work was conducted virtually through a unified and branded website.

BLNDIY Citizen Science was created to follow a structured weekly schedule. Users were asked for experimental input on this website once a week for ten weeks from May 18th, 2020 through July 25th, 2020. The content spanned exploring foundational interests in language science through creating a research question, discussing experimental design, analyzing data, and making final conclusions. Though weekly participation was encouraged, the site allowed for drop-in, drop-out participation; there were no prerequisites for engaging with the material, and all content was openly available throughout the duration of the project. These interactions operated in cycles of participant input and researcher guidance. The program began with background information allowing for public discussion on general topics of interest, which then

allowed the research team to provide help in turning those ideas into research questions; these research questions were then voted on by the participants, which allowed the researchers to publish background review materials and questions about experimental design; a public vote then made these design decisions, which prompted the researchers to create stimuli; and so on.

This is the truly novel principle behind this project. Not only can the public be involved with real scientific work beyond the role of the research subject, but they can also be active contributors to every step of that research process on the topic of their own interest. Participatory action citizen science programs have been conducted in the past and share this partnered-design approach (Katapally, 2019); however, those efforts focus on developing local community interventions and policies in tandem with community members, as opposed to this project's wide audience and educational focus on language science content delivery for the improvement of science attitudes.

Design & Website Content

This DIY citizen science initiative was conducted entirely online. A new website dedicated to the project's content was designed through the u.osu.edu system provided by Ohio State University (for more information, see https://u.osu.edu/blog/2013/08/29/what-is-u-osu-edu/). This system runs on a modified version of the WordPress architecture and administrator suite, and it is free for associates of the university as well as better controlled for research privacy. Using this suite, I created and maintained the full public-facing website, including structure, individual postings, comment moderation, visual design, and video features. Figure 1 is a screenshot of the main homepage and navigation options representative of the final week of the program.

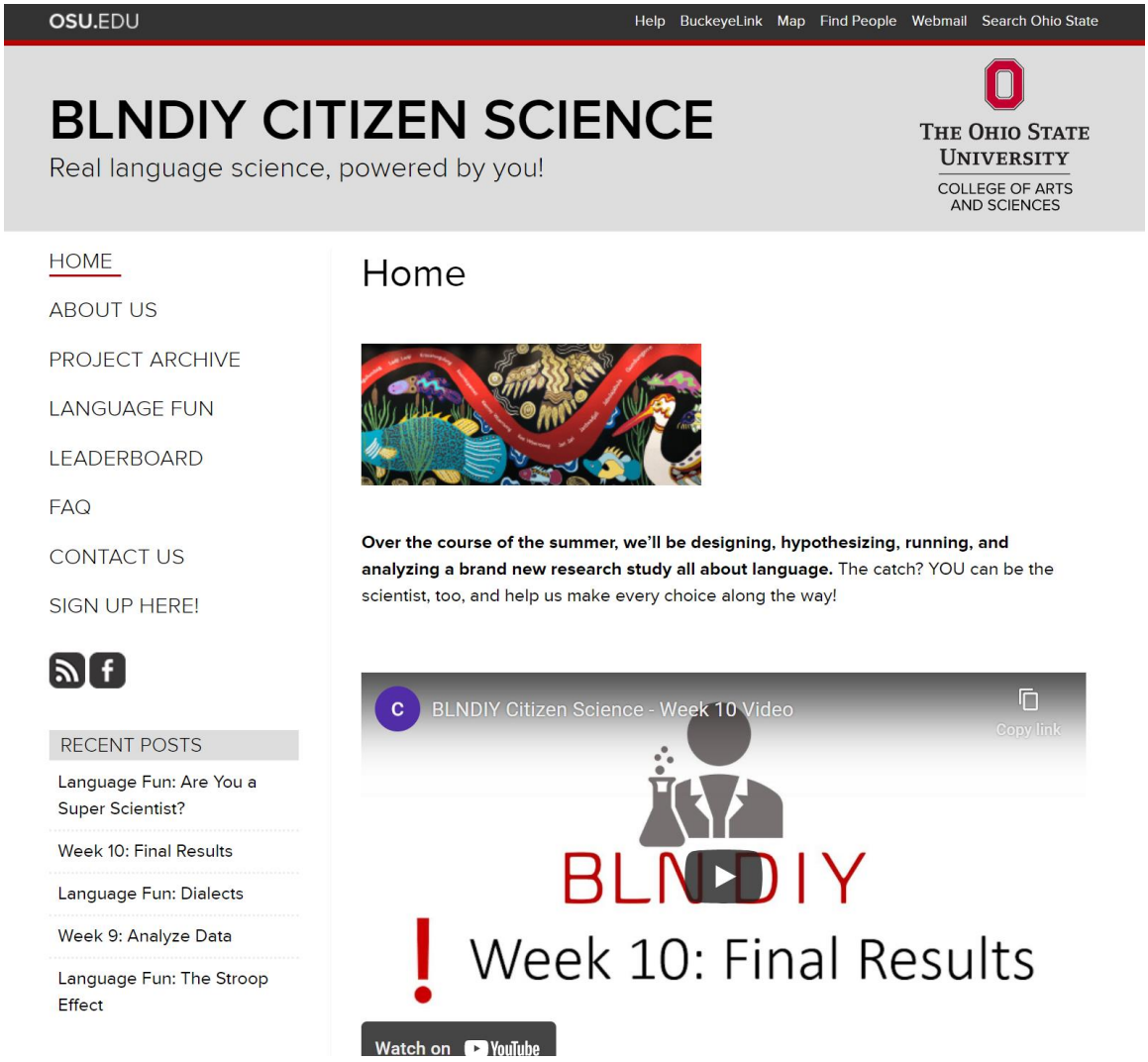

Figure 1: the BLNDIY Citizen Science homepage showing general site structure. Note the navigation and 'Recent Posts' widgets on the left side of the screen. This image was taken at the end of the program and includes a final summary video that wasn't present for most of the summer.

Below the initial greetings and cursory information on the homepage is a project timeline (see Figure 2). In addition to immediately marketing the weekly nature of the program and noting which step is currently being investigated, clicking any of the images will navigate the

web browser to that appropriate content. This visual feature kept track of the program's overall progress and served as an intuitive roadmap to access any given week's content for review.

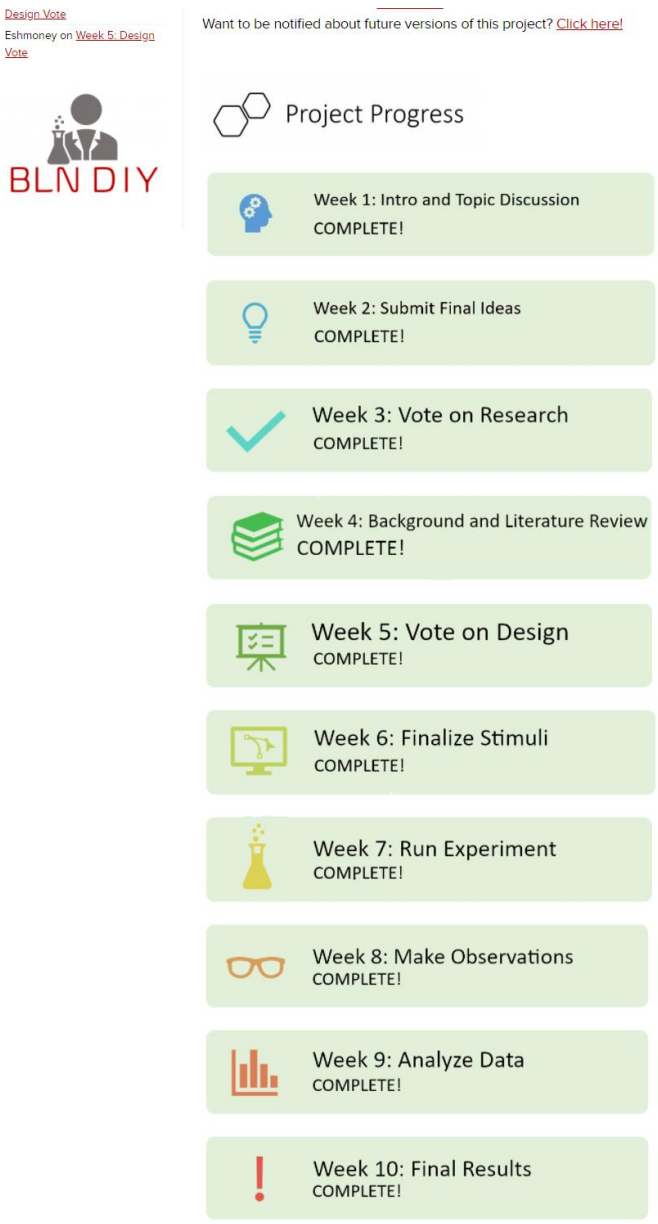

Figure 2: the homepage's progress timeline. During the program, each week was color-coded to indicate which had been completed, which had yet to be completed, and which was current.

Aside from cursory information provided on the program itself, notable features are the ‘Project Archive’, ‘Language Fun’, ‘Leaderboard’, and ‘Sign Up Here!’ tabs in the left-side menu. Also included for the duration of the summer but since removed was a ‘This Week’ option that would take readers directly to the most current weekly post for the research project. Each of these sections will be explained below.

The primary focus of this project was the interactive experiment creation, which was updated weekly through the This Week tab. Upon selecting this option, users would be taken to a singular webpage with the research-focused background information, updates, and weekly crowdsourced tasks based on the next needed step in the scientific process. Figure 3 shows an example of one such weekly research post.

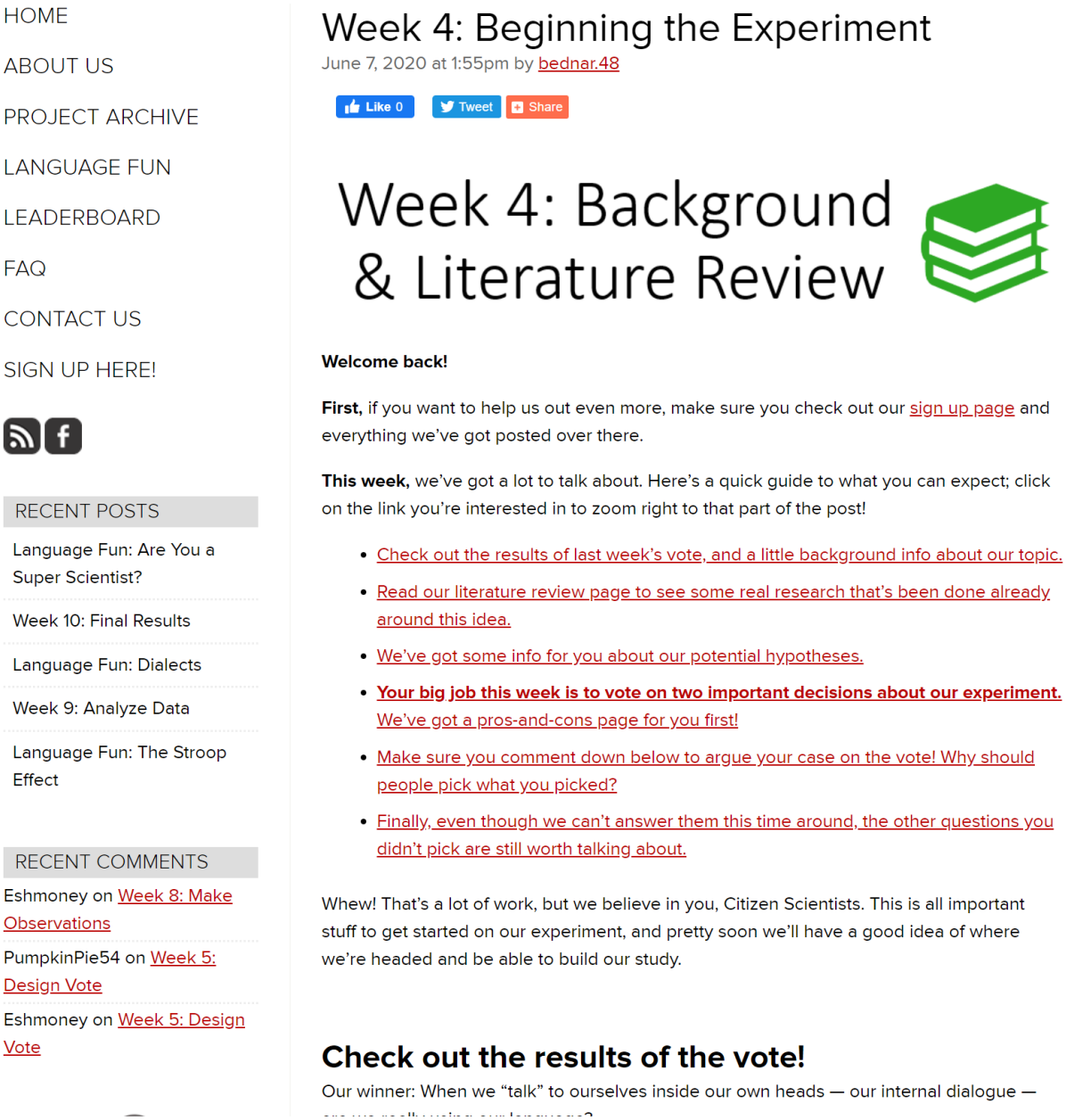

Figure 3: The Week 4 research post's introductory material. Each week's content would provide an overview of that step's goals, precursory information on linguistics or experimental concepts, an interactive opportunity for participants to contribute to the developing project, and a moderated comment section.

Content on these pages would include reflections on the state of the experiment, introductory information on scientific processes, a call-to-action for the week's work, and an invitation for comments in the provided discussion area, as well as occasional media additions produced for this project like videos or diagrams. These posts were written in the short period following the results of the prior week's vote or contribution, thus allowing for up-to-date and live information made specifically in reaction to the choices of the citizen scientists. This process was accompanied by the visual progress bar on the homepage that indicated how far along the work had been progressing, which could be clicked to navigate immediately to any given week's content. As the project progressed and new content was published, the prior week's work would be transferred to the Project Archive for future viewing and the sake of clearer organization.

The Language Fun section of the website was included for two main purposes: to keep visitors engaged by providing more frequent updates of content and to promote the principles of language science through interactive demonstrations. This included quizzes, games, and activities focused on observable linguistic phenomena and founded in the existing body of informal outreach demonstrations on the topic. Figure 4 shows an example Language Fun activity, created in the survey platform Qualtrics and linked to from the website page. While only tangential to the goals of the project, these weekly activities were designed to both educate participants on the wide variety and depth of language science as a field of interest as well as encourage continued engagement with the website.

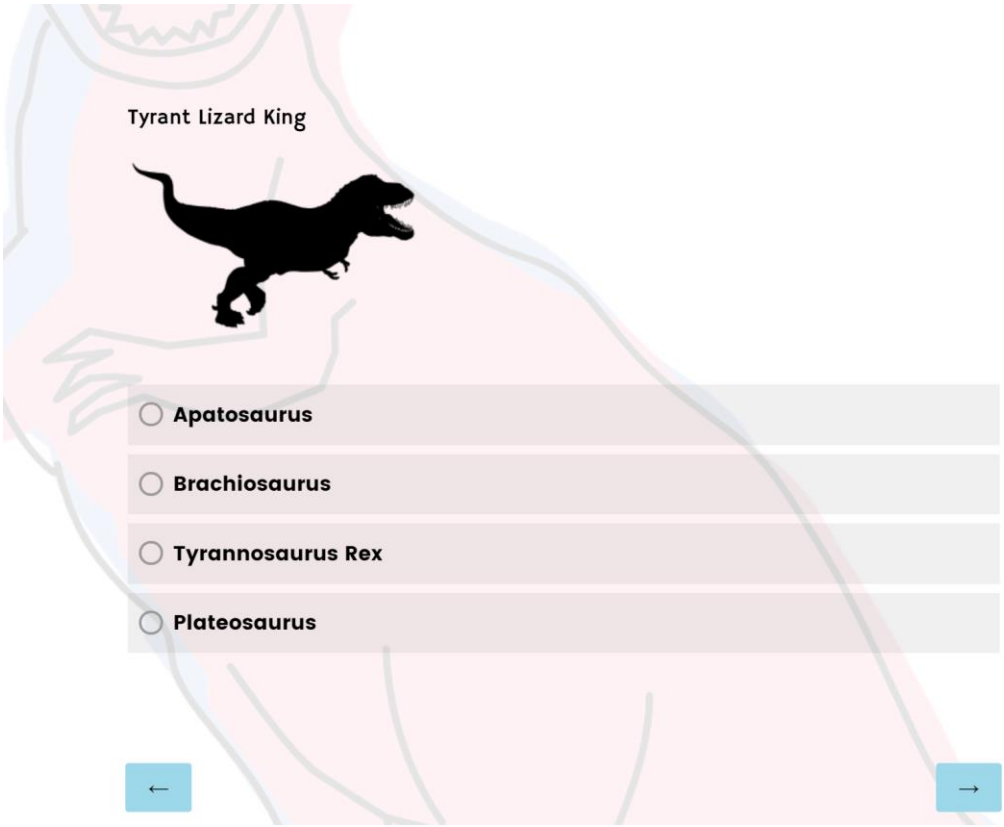

Figure 4: Language Fun demonstration example, in this case an activity connecting scientific naming conventions and word roots to dinosaurs. Quizzes and games were designed to teach linguistics concepts as another motivator for website visitation.

The Leaderboard section had a similar goal: by participating in a published post's comment area or through completing each week's task, users could pick a screenname and be recognized for their continued work as citizen scientists. Each counted contribution would increase their ranking on this leaderboard, moving their username up in the list above others who had not participated as often and promoting them to new titled tiers of recognition (starting with 'Wuglet' as a beginner and becoming a 'Mad-Scientist' once reaching 10 total contributions). Like Language Fun, this was intended to serve as a motivation for returning to the project

website, but also as motivation for completing the given assignments for designing the research project.

Finally, the Sign Up Here! page allowed visitors to formally choose a screenname for the Leaderboard as well as enroll as an adjacent research participant in a partnered evaluation study to this discussion on program design. Citizen scientists did not have to join the formal research to enroll in the outreach for the Leaderboard, nor were they required to enroll in research to view or contribute to any of the content on the website. This was noted as an optional extension to the overall DIY system, not an integral part of the creation of the experiment. All website posts provided moderated comment sections for participant discussion, but citizen scientists were unable to privately contact other users. Participants were required to be 13 years or older (with parental consent required for participants under 18) to select a public username.

These pages were all monitored by basic tracking measures to record visitor statistics. This includes pageviews, countries of origin, time of visit, and other rudimentary information. Site traffic was an important indicator of the successes and failures of this project's overall design, as the rates of retention, overall geographic reach, and trends in pageviews can help determine the impact of a project like this.

For additional reference on website content and design, see u.osu.edu/blndiy for the full project archive. The URL is active and accurate as of this document's date of publication.

Target Audience

The intended audience for DIY citizen science was rather broad in scope. All content was designed to be approachable and appropriate to a variety of age groups and backgrounds, providing varying degrees of depth and complexity to be able to achieve some extent of suitable

outreach for any given user. Good informal science provides messaging that attempts universality, and outreach focused primarily on attitudes is no different. Promotional messaging was targeted simply to those interested in helping to make a summer research project in tandem with language scientists.

However, this model does introduce unavoidable restrictions to access. Most immediately is the digital setting for the project; a reliable internet connection and compatible device were required to be able to continue engaging with BLNDIY Citizen Science. Public resources like library computers do help to bridge this gap of access, and simple media with written content like that featured on the website are not especially resource intensive. Nonetheless, given that an ideal experience involves repeatedly returning to the website every week, the inconvenience of not having a personal device likely limits the helpfulness of such resources. Though demographic data was not collected beyond computer detection, it is reasonable to expect that most participants were not of lower socioeconomic status and had adequate available leisure time.

Promotion

Though public health restrictions during the COVID-19 pandemic limited promotional activities, digital advertising in various forms was the basis of building an audience for the project. The citizen science collective group SciStarter (https://scistarter.org/) allows for studies seeking public input to promote to individuals and families interested in participating in science. BLNDIY was listed on this website as a joinable project before the public launch of the program. This allowed for initial promotion to reach participants who were already interested in citizen science programs. Specific promotion was targeted to site members in the greater Columbus, Ohio area who might have other interests in the research lab and Ohio State University.

Existing avenues and partnerships for lab promotion also proved useful. Social media, particularly Facebook, provided initial launch postings to be shared not only with team member accounts but through association with other language science laboratories and science pages. The notice for the project was also shared through Ohio State's linguistics faculty and student email lists, which provided word-of-mouth promotion.

Additionally, individuals who commented or interacted with the website were prompted to provide their email address. With their permission, this was then added to an email update list. This would automatically notify included users when new posts were published on the website, including the weekly research prompts and Language Fun activities. This was a relatively small aspect of user engagement efforts.

Program Review

Website Statistics

To begin examining the strengths and weaknesses of BLNDIY's project design, it is important to consider the tracking information provided by the website's analytics program. The first category of website information examined was the overall site traffic. Figure 5 shows the generated statistics from the official launch date of the project through the official end date. The purple line, or the line that is the higher of the two, represents overall pageviews, while the blue or lower line is the number of unique users or devices.

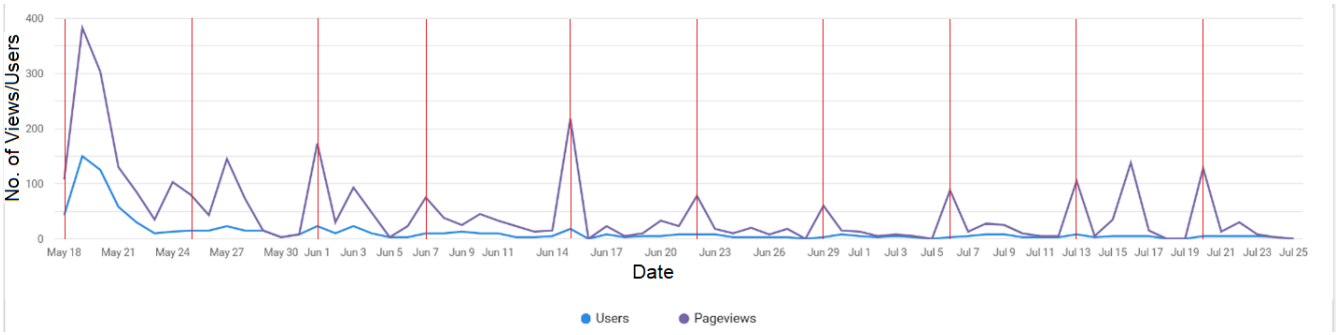

Figure 5: Website traffic across the duration of the project. Note the red bars which indicate the dates when a new weekly research update was posted.

Naturally, the very start of the project was its most successful period. The peaks in pageviews across the program dates correspond closely with the weekly postings of new research-focused prompts, rather than other site content. By the end of the project, there were only a handful of consistently returning users, but the total program duration saw approximately 979 people who visited at least once. On the website, users viewed an average of 2.58 pages per session, or essentially a reasonable movement from the homepage to one or two other posts. They stayed for an average time of two minutes and forty-one seconds, a rather low overall time for content that would likely take at least twice as long for thorough reading.

Another metric worth considering is the geographic reach of the project; where were people viewing this from? While we only have data for rather broad regions (at the level of countries), Figure 6 shows tracked user location.

Figure 6: Site visitor nationality across the duration of the project, with the top represented countries. Areas in blue marked on the map indicate at least one visitor from that region.

As expected from a U.S.-based and English-language website, most site visitors were from the United States. However, there were users from countries around the world, and at least one pageview from all six inhabited continents. This was more than expected, and it suggests value in multilingual or regional variations of DIY citizen science projects.

Given that there were several users from unexpected places, this observation leads to the question of where these users may have come from on the internet. Though the website statistics are not specific about how any given user found the website, there is available data for the general referral sources from across various other platforms. Figure 7 lists known referral methods across the duration of the program. Note that the total number of referrals does not match the total number of users reported earlier in this section. The discrepancy is due to limitations with the built-in analytics tracking system, but this information still provides insight into the overall patterns of traffic sources.

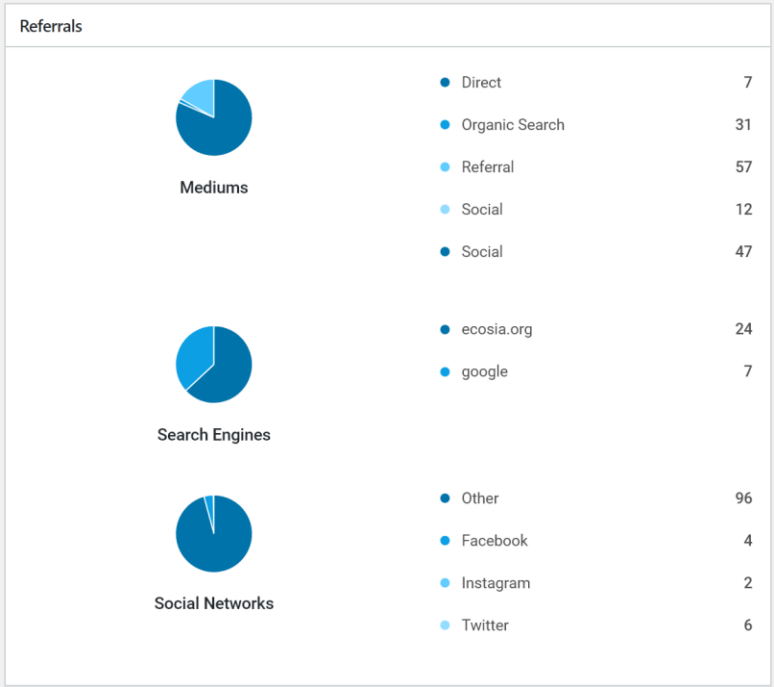

Figure 7: Site traffic referrals. Mediums shows the broad internet categories that drove website visits, while Search Engines and Social Networks show visits per relevant platform.

There was no single source that most often led traffic to the project website. At minimum, this information demonstrates the varieties of referrals that can lead to a developed userbase. It is worth investing across platforms, as social media, search engines, and other websites can all provide an audience for a citizen science initiative.

As alluded to when considering the overall site traffic, not all content was given equal attention by the userbase. Figure 8 lists the ten most-viewed pages on the website across the duration of the project. Given that some of these pages were available upon the launch of the project while others were added later, earlier content has the advantage in this overall count.

Rank	Page	Category	Views	Avg. Time (min:sec)
1	Main Homepage	Navigation	984	1:51
2	Week 1	Research	324	11:14
3	Sign Up	Navigation	144	8:09
4	Research Home	Navigation; Research	138	0:12
5	Leaderboard	Navigation	117	2:29
6	Week 2	Research	112	6:24
7	Week 3	Research	80	4:28
8	Week 4	Research	74	3:38
9	Language Fun Home	Navigation; Activity	69	0:00
10	Week 6	Research	48	0:00

Figure 8: most visited pages by view count, along with average view time. Category breakdown includes 'navigation' for main landing pages from the side menu, 'research' for main project pages, and 'activity' for supplementary educational content.

There are two main categories of pages represented in Figure 8: general site information and weekly research updates. The most popular page was of course the homepage, and the navigable pages in the sidebar were also well-visited. However, weeks one, two, three, four, and six of the research project are also represented in this top ten list. This is particularly notable for the fact that they were more popular than some of the other sidebar items, including 'About Us' and 'FAQ'. However, the page views for those project updates decreased consistently every week, with 'Week 1' receiving hundreds of views and 'Week 6' only registering 48 visits. Notably, while the Language Fun section had some visitors to the general section tag, none of the interactive demonstrations reached the top ten, unlike the project updates. This is an overwhelming show of preference for the research content as opposed to the secondary educational materials of Language Fun.

Discussion

Overview

This being an initial run of this new concept, the present evaluation is most concerned with audience perceptions and engagement with this project. Most data will be from the tracking analytics of site interaction. This serves to inform future attempts at DIY citizen science to better prepare for anticipated issues and design choices. By observing site traffic and content contributions, we can begin to refine the methodologies for good digital science outreach that can fully serve the goal of changing science attitudes.

Overall, engagement with the project was successful when present; the first pitfall was the gradual but consistent decrease in audience presence over the duration of the project, and the second is the low average engagement time with the posted content. While not comprehensive enough, the promotional efforts that were used did appear to drive traffic to the program's website. The preference for research-focused content shows that visitors are more motivated by the main weekly activities than secondary educational content. Linguistics did prove to be an area of interest for participants, and the geographic breadth of the participants warrants further consideration in future content creation.

Though there are clear areas of difficulty in this first attempt, the core group of participants that maintained interest provided interactions of continued quality that afford us with an accurate picture of what this kind of DIY citizen science project can and should look like in real-world practice.

Outcomes

The tracking information reveals some strengths and some weaknesses to this initial format. The most striking result is the overall number of website visits; while there was an expected initial spike from the project launch on day one, the amount of site users decreased consistently over the first five weeks to then remain steady with a smaller core group of supporters. While this participation never reached zero, allowing the project to continue, such a drop is obviously a weak point in this initial design. The drop-in, drop-out nature of traditional citizen science methods is overall positive, and it is not necessary for all participants to stay for the duration of the program. However, while DIY citizen science is still asynchronous, it is certainly best experienced by contributing to the project from the beginning to the end. The full impact of creating a science experiment is reached upon seeing the final results and losing so much of the initial userbase is not ideal. While the numbers from week to week did fluctuate, there is still a clear downward trend as the program continued.

The average site visit time was two minutes and forty-one seconds. While this means that participants were engaging with the content at more than a cursory glance, this is a rather short time given the depth of the materials provided. The posted content was created to be digestible and the site designed to be quickly navigable, but given that many users naturally read for a shorter period than even the numeric average, this is probably not enough time to dive into much more than the briefest pieces of information. Either the readings should be shorter to accommodate this timespan or other measures taken to ensure longer visits.

Though it could still be expanded in its scope, the variety of preliminary promotion conducted for this program did seem to affect the sources of website traffic. Given that multiple search engines, social media platforms, and direct URL links all report significant numbers of

referrals, there seemed to be no single primary driver for where visiting participants learned about BLNDIY Citizen Science. Because of this, it appears that programs like SciStarter, announcements through laboratory and associated social media accounts, calls for word-of-mouth spread, and messages through university mailing lists can all contribute to finding an appropriate audience.

The Language Fun content was some of the less-engaged content on the website. This indicates a general focus and interest in the research portions of the program. While these outreach activity pages did receive some views, the primary motivation for continued site interaction was not supplementary games and information but instead the science itself. While disappointing for the sake of our content creation, this is promising for continued public engagement with research for its own value. Extra bells and whistles likely do not hurt with audience interest and retention, but they are also likely unnecessary and distract from the science research that remains the primary content in such a project. The research update posts provided the significant pageview spikes visible in the website tracker, and the overall engagement time was longer for this content as well; this is what users returned to see. In addition, this secondary content is not especially important for the goal of improving science trust, and the research work fulfills this need regardless. Citizen science research itself can successfully disseminate information into communities of participants, not only involving them in the scientific process but helping them to critically consider the issues being presented to them in a way that can change their beliefs and behaviors (Asingizwe et al., 2020). Perhaps that core information is therefore all that is needed.

As predicted by other linguistics outreach research, language did prove to be a considerable area of interest for participants. While the work sourced from the participants was

focused on the scientific design itself, the initial discussion on the group's areas of interest in language produced a number of varied perspectives and questions, ranging from multilingualism's impact on language acquisition to emotions in language, among others. While this engagement is partially due to the larger group of participating users toward the beginning of the program, meaning that more interaction was a natural consequence of more people commenting and voting, the comments were consistently several sentences long and the variety of topics surprising. In addition, while not all suggestions were refinable into testable research questions, this variety and consideration support the idea that language is an area that is approachable and accessible to the public as a scientific field.

Additionally, the project had a surprising geographic reach. While the planned audience was not specifically restricted to any area or national group, the content being in English and the project's origin being in the United States certainly lend to having more reach in this country specifically, perhaps including other English-majority countries. Though these expected populations did have the largest total participation, significant traffic came from Spain, Egypt, Argentina, and China, among many others. Perhaps regional variations in addition to multilingual content could provide better outreach to groups outside of the primary project demographic, also promoting the value of multilingualism and the diversity of language itself.

Recommendations for Improvement

The first issue with this implementation of DIY citizen science is the duration of the program. 10 weeks is simply too long to retain an engaged audience with this format. The overall traffic to the website decreased consistently week-by-week, only leaving a few dedicated members by the time the experiment had concluded. This issue may be ameliorated through more persistent messaging or notifications, or through joining a more established system

alongside other initiatives with consistent users, but a shorter span of time would still be advisable for the sake of public interest and investigator effort. Similarly, although there is still merit to including content that breaks up the intensity of pure research posts, less time should be devoted to readings or activities like the Language Fun section. Interactive quizzes and games about topics in linguistics were added to the Language Fun area of the website every week a few days after the relevant research task, but they received far less attention overall. Though they may still be meaningful educational tools in the right context, they served a relatively small purpose in this program. Alternatively, if this content is specifically designed to be integrated within the research portion of a DIY citizen science program, then it may prove to be more useful and instead aid with audience retention and depth of the outreach materials.

A more complex set of infrastructures for the website system would also be a recommendable change. Though this was an anticipated limitation to the trial run of this current project, the weaknesses of a rudimentary website creation platform proved to impact the quality and visual style of the content. By instead working with professional developers and a more robust format, additional tools could be implemented that would improve the presence and impact of such a program. This may include a complementary app that allows for push notifications, a more streamlined and flexible presentation and style for content updates, a system with specific logins and accounts that automatically track participation and allow for a more customized user experience, and so on. Personalizing the citizen science experience to individual participants by tracking their participation through user accounts improves the quality of their contributions to the project (Cedazo et al., 2020). Introducing badges or achievements, a formal point system, promotional levels, and a coherent and aesthetically competent infrastructure have all been shown as promising elements that can ‘gamify’ citizen science and

improve engagement (Kanner et al., 2018). None of these suggestions impact the baseline working principles of the project, but they would certainly reduce the manual load of its content and improve participants' experiences.

Given the rather rapid nature of internet browsing and the goals of informal science outreach, less technical content may be advisable for future versions of this project. While the objectives of DIY citizen science include gaining a working understanding of how real research methods work, deep technical descriptions are simply less engaging material and may have contributed to the drop off in participation and limited webpage retention times. People expect to have fun doing citizen science, and while that was a primary goal of this program, it remains difficult to create engaging media on the intricate details of data analysis and the selection of an analytical model, for example. Working in fine detail on scientific work is generally more tiring and tedious than thinking about broad topics or plans. Such information should not be dropped entirely as that would be antithetical to the goals of engaging participants in the experience of real research. However, lowering the intensity or duration of that focused and challenging content, or perhaps removing it to an optional section or track of interactions in a modular approach, may provide a more engaging and less intimidating experience.

Significant efforts should be put toward project promotion as well. While the initial audience was a sizable enough group, the mechanisms of participant-led research operate much more thoroughly and excitingly with as big a group of people as possible. Though this was partially impacted in this run of DIY citizen science by concurrent world circumstances, a good amount of time should be invested before the program launches in establishing a group of volunteers or followers that are aware of the project and fully intend on participating. This might include dedicated channels of social media, partnerships with other educational or language-

focused institutions, and perhaps even paid media advertising. An online website is uniquely capable of handling large numbers of participating members, meaning there is no significant limitation on recruitment that needs to be respected. Programs like this have the potential to support incredibly large populations of citizen scientists and are seeing a surge in popularity for both professional researchers and the public at large (Robles et al., 2020), so promotional materials should focus on involving as many participants as possible.

Expanding Scope

Because of the flexible design and structure of a DIY citizen science program like this one, there are additional customizations and changes that are worth considering in future versions of its implementation. Though the virtues of language as a medium for science education are clear, this model of DIY citizen science is easily adaptable to other fields of research. Engaging participants on topics from other sciences would allow them to try new things and see new perspectives on the experimental process. An obvious connection would be to cognitive science as a whole – much of this infrastructure would translate directly to other matters of the mind, including memory, cognition, personality, and social motivation. While language is an approachable and near-universally experienced topic, not everyone can be expected to find it intellectually stimulating. Working with other fields might allow for the inclusion of participants that would otherwise be uninterested. While these methodologies could certainly be extended to entirely unrelated areas – be that the ‘hard sciences’ like physics or the social sciences like economics – that move would require some reimagining to accommodate different unfamiliar ideas or different standards of experimental design. It would also be worthwhile to consider other types of language research, particularly through the development of a less Anglocentric and more multilingual angle to a project.

One particularly intriguing option would be the creation of a DIY citizen science modular system that would allow other educators or researchers to create their own versions of this program more easily. Using generalized videos on scientific methodologies and a structured series of project steps, other teams could develop and plan their own implementation of this novel approach according to their outreach goals and the needs of their field of interest. It is easy to imagine this platform fitting the demands of many different creators, specifically including scientists in other fields of research. Consistently providing this video form of media may also help to engage users who better connect with different approaches to content generation than simple text features.

The issue of audience retention could also be improved through integration with formal classrooms. Citizen science, outside of the DIY angle, has already been applied to classroom environments, but it needs to be carefully guided to ensure that students are finding meaning in their scientific practices, a detail crucial to making memorable interactions that might change attitudes. An online DIY citizen science project can be readily incorporated into a formal curriculum, in particular because of its accessibility in the physical classroom and support from guiding project scientists (Hayes et al., 2020). Having an audience that is being guided by an additional instructor would naturally mean greater numbers of initial participants and a required series of ongoing contributions. However, this raises the issue of compulsory citizen science perhaps making the informal aspects of these programs less enticing, working against our goals of building science understanding and interest. This does not appear to be an issue in practice, though, and classroom integration with citizen science has had positive results through its more traditional implementation (Straub, 2019). This online, DIY approach can even straddle informal principles with formal assignments by allowing students to lead their own interests through

participatory work, for example by submitting their own thoughts, feelings, and focusing on the content that interests them. Informal outreach can be successfully integrated with formal settings in collaborative ways that bolster the benefits of both interests (Hofstein & Rosenfeld, 1996). While this iteration was widely open and not specifically tailored to any given group, there could certainly be a continuation of its vision that focused on working in parallel with collaborating classrooms or other groups. Such a version might include explicit changes that encourage class participation, like classroom instead of personal accounts or school-wide competitions on the website, but it may be enough to simply provide professional educators with a short guidebook of possibilities for implementing the project as part of their overall science curriculum as the method already stands.

Limitations

The specific timing of this project inevitably affected its work to some extent. Given the unexpected restrictions on in-person gatherings due to the COVID-19 pandemic overlapping with the planned timeline of this project, all project research was conducted solely online, which altered the original plan of running the designed experiment in a physical laboratory. This also restricted community outreach for promotion in physical spaces prior to the project's start date. In addition, a significant portion of this work was conducted following the police killing of George Floyd and the racial justice protests across the United States that followed. While these concurrent events had little impact on the functioning of the program itself, they understandably provided a difficult background and environment for sustaining engagement with language science.

It is worth noting the relative lack of controls for this program's evaluation. While the larger argument being made here is that all the foundational aspects behind this work are

important to its purpose, it remains to be seen how some of the novel components at work here may be extended to other contexts. While we have significant evidence that language science is a valuable tool for science outreach, for example, we do not know the specific impact of just that subject area on participant-led, DIY citizen science methods. This is a necessary evil, however, because of the new ground that this work covers, and all design decisions were made in tandem with the established foundational principles of informal science materials. Only by producing future iterations and continuing to evaluate their successes and failures will we be able to tell which factors were the most important. The website tracking information is provided by built-in analytics features in the website's editing program, powered by WordPress. Throughout the data collection, there were several known issues with the reporting of this information from the website platform. Though we have reason to believe that the general information that it produced is still useful for considering the traffic and impact of this study, third-party online analytics would have provided deeper insights into this angle that we unfortunately do not have. This includes more detailed demographic information such as gender and age, engagement per each individual participant, and the features on each page that were viewed and used the most (such as which videos were played, or which links were followed). Information like this can help program designers to create a more curated curriculum and improve the user experience.

This discussion also does not directly address the effectiveness of the project on changing science attitudes, which is the primary motivation of this program. The current paper is more focused on the mechanics of creating a DIY project for potential educators and researchers. However, these concerns are alleviated both by the adjacent work that is to be addressed elsewhere as well as the considerable and investigated merits of citizen science and informal outreach methods regardless of format. Citizen science and inquiry-based curriculum have

previously shown student improvements in science understanding as well as the development of civic interest in scientific issues (Condon & Wichowsky, 2018). There is every indication that a project like this does work, but that is not the primary concern of this writing.

Conclusion

Citizen science is a powerful tool for both improving science trust and attitudes as well as involving the public with the creation of new scientific knowledge. Extending this value into DIY citizen science that focuses on community interactions and participant agency furthers the goals of such programs in general and shows great promise for additional implementation. Despite the complexity of this approach and the work to be done to perfect it, using peoples' own interests, the principles behind informal science education, and the approachability of language science as a gateway all prove to be encouraging as methods of improving science trust and attitudes.

Notably, though the full process of DIY citizen science is best experienced week-to-week through active and ongoing participation with the project itself, the digital setting of a website and the inclusion of an archive have the additional benefit of publication in perpetuity. While votes and comments left after the project has finished have less impact or relevance, all the outreach content and the process of building the experiment are left available to read even to those who may have missed the initial run of the program. With this messaging remaining available to the public, its efforts to improve science trust and attitudes are not limited simply to its strict duration.

Overall, though an imperfect trial run, this DIY citizen science program shows promise as a worthwhile combination of traditional methods of citizen science with novel approaches to participant-created research projects. Given additional considerations and changes based on the shortcomings of this first attempt, particularly focused on audience retention and participation, outreach programs that follow its path are likely to improve science trust and involve the public in a new level of scientific work.

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